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Review Paper

Nutrient requirements and feed resource availability for pastoral cattle in the tropical Africa: A review

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Abstract. The objective of this paper is to review the nutrient requirements and feed resource availability for cattle in the tropical Africa. Cattle require consistent source of protein, energy, minerals, vitamins and water to maintain productivity and health. The nutrient requirements of cattle can be broken down into maintenance, lactation, growth and reproduction requirements. Forages have the ability to supply all the energy needed to maintain highly-productive cattle throughout the growing season, but only managed intensively. Legume-grass pasture will easily have protein content greater than 18% during the vegetative stage, as plants mature, the nutrient values lowers. Cattle require 3 to 30 gallons of water per day, at the rate of one gallon of water per 45 kg body weight during wet season and two gallons of water per 45 kg body weight during hot weather. Supplementation of low quality roughage is done by feeding limiting nutrients in the form of concentrates (energy and protein), minerals, non-protein nitrogenous (NPN) substances (urea and poultry litter) or green forages. However, in Nigeria, forage quality and availability vary greatly from season to season which however, affect the output of the animals. The nutritive value of pastures fall rapidly with maturity and, during the dry season, the available feed is lignified. Likewise, protein, vitamins and mineral elements are limited in grassland pastures during the dry season. Crop residues, by-products and browse plants remained the most outstanding feed supplements for cattle and other livestock in Nigeria.

Keywords: Nutrient requirements, feed resource, availability, cattle, tropical Africa.

INTRODUCTION

Cattle are natural grazers and possess remarkable ability to digest plant carbohydrates that are generally indigestible to most other mammals (Church, 1977; Babayemi et al., 2014). It is natural then to assume that grazing is the best way to supply a nutrient to growing cattle (NRC, 1984). Cattle require consistent source of protein, energy, minerals, vitamins and water to maintain productivity and health. The nutrient requirements of cattle can be broken down into maintenance, lactation, growth, and reproduction requirements (McBride, 1988).

Nigeria has a land area of 92.4 million hectares of which about 44% are under permanent pastures, which support its domestic ruminants of over 101 million (Shiawoya and Tsado, 2011). It is estimated that only about 3% of this number of animals are reared on improved pastures; the remaining 97% are raised on low nutrient native pastures and farmlands (Okorie and Sanda, 1992). According to Kallah (2004), grazing lands in Nigeria, including natural wetlands (fadama), grass and woodlands and forest reserves, are estimated to cover about 32.42 million hectares, while cultivated croplands amount to about 39.41 million hectares. These lands provide substantial amount of forage and fodder as a major source of feed, for the country's ruminant livestock, both domestic and wildlife.

In Nigeria, forage quality and availability vary greatly from wet season to dry season which however, affect the output of the animals (Ogunbosoye and Babayemi, 2010).

The nutritive value of pastures fall rapidly with maturity and, during the dry season, the available feed is lignified. Likewise, protein, vitamins and mineral elements are limited in grassland pastures during the dry season. The nutritive value of any feedstuff is determined by its chemical composition and degradability and this is related to the forage and its environment. The rate of acceptability of forage is related to the readiness to which the forage is selected and consumed. In spite of the infertile soils and hostile climatic environment, ruminant livestock survival in Nigeria has depended largely on the extensive native pastures, browses and farm crop residues across and within the various agro-ecological zones. Nigeria's forage and fodder species vary widely and spread across the major agro-ecological zones of the country (McBride, 1988; Byers, 1990; Babayemi et al., 2014). Extensive areas of Nigeria's grazing lands are composed of indigenous forage species with their various botanical characteristics. Most of the species grown, until of recent, are of local varieties that often have very low yields. Long periods of cropping, rough topography and frequent bush burning, among other factors, have given rise to mixed tree, shrub and grass vegetation in the savanna zones of the country. The grasses are composed of both annuals and perennials, and the trees show features characteristic of plants growing in low rainfall areas. Various nutrients and minerals, such as nitrogen, phosphorus, potassium, among others, have also been found to be a key limiting factor in the proper development of our forage and fodder crops, and hence efficient utilization of these crops by our livestock (Babayemi et al., 2014). The objective of this paper is to review the nutrient requirements and feed resource availability for cattle in the tropical Africa.

CHARACTERISTICS OF CATTLE NUTRITION

Dry matter intake of pastoral cattle

Forage is the most economical ruminant feed during the grazing season (Virginie et al., 2009; Kubkomawa et al., 2013). In pastoral systems there is forage diversity but the pasture is not established by man; they are natural (Rook et al., 2004). In such diverse landscapes, the ability to determine dry matter intake (DMI) and digestibility is a valuable area of study due to its impact on the nutritional status, productivity and health of animals as well as adding to our knowledge of cattle foraging behavior and impact of seasons on biodiversity and the dynamics of the plant community (Kelman et al., 2003; Ali et al., 2004). A considerable amount of research has been conducted in the temperate region using long chain saturated hydrocarbons (N-alkanes) as markers to estimate feed intake and digestibility (Dove and Mayes, 1991; Mayes et al., 1995; Dove and Mayes, 2006). N-alkanes are saturated, aliphatic hydrocarbons with length varying from 21 to 37 carbon atoms (Premaratne et al., 2005). They are part of the cuticular wax of plant leaves and are usually part of the ether extract which are indigestible in nature. Grazing time alone cannot be used to determine DMI of grazing animals because intake rate also must be considered (Rutter, 2006).

Environment also plays an important role in resources utilization. On one hand, animals have a memory of food allowance, location and distribution. On the other hand, the rearing practices can explain the ability of cows to graze specific environment such as mountain slopes depending on the animal breeds. Interaction between animals in the herd is sometimes cited to explain difference in animal grazing behavior. Sibbald et al. (2000) reported that on homogeneous vegetation, total time spent grazing by Scottish blackface sheep is higher when space allowance is high (200 m^2 and 50 m^2 per head) without impact on herbage intake or digestibility. They conclude that the relationship between time spent grazing and space allowance can be used to explain the extra activity required to maintain the group cohesion when space allowance increases. Working with indigenous, cross bred and exotic cattle using an all-roughage ration of Giant star grass, Ikhatua and Olubajo (1979a) obtained digestible energy (DE) and metabolizable energy (ME) requirements for maintenance of 255.28, 194.18 and 208.58 Kcal DE/day/wt and 130.37, 125.10 and126.69 Kcal ME/day/wt for White Fulani (Bunaji), German Brown NDama and German brown steers respectively.

Grazing ruminants prefer eating mixed feed resources such as grasses, legumes and browses (Rutter, 2006). In such diverse landscapes, the ability to characterize diet contents is a valuable area of study due to its impact on the nutritional status, productivity and health of animals as well as adding to our knowledge of ruminant foraging behavior, impact of seasons on biodiversity and the dynamics of the plant community (Kelman et al., 2003, Ali et al., 2004).

Energy requirements of cattle

Major determinants of animal's energy requirements are weight, body condition score, milk production, rate of growth, level of activity and impacts of climate (Byers, 1990; Babayemi et al., 2014). Fresh grass, with high quality grass-legume can meet energy requirement of growing or lactating cattle in the wet season. Energy supplementation on pasture helps in maintaining high grains and milk production. Dry cows can subsist on lower quality feed stuffs and maintain an acceptable body condition score in order to be successfully bred and deliver a healthy calf. Energy supplement such as grain can result in better protein digestion and therefore higher milk production and greater weight gains. Forages have the ability to supply all the energy needed to maintain highly-productive cattle throughout the growing season, but only managed intensively. Legume-grass pasture will easily have protein content greater than 18% during the vegetative stage, as plants mature, the nutrient values lowers.

Supplementation of the all-roughage rations with protein supplements, Ikhatua and Olubajo (1981) observed a reduction in both the digestible and metabolizable energy requirement of the three breeds of cattle under investigation. The DE and ME required values for maintenance being 211.76, 148.61 and 161.77 Kcal and DE/day/wt and 118.71, 120.68 and 84.63 Kcal ME/day/wt for the Bunaji Crossbred and German Brown, respectively.

Protein requirements of cattle

Protein is one of the main building blocks of the body. It is usually measured as percentage of Crude Protein (CP). It is a major component of muscles, the nervous system and connective tissue. Protein is composed of chains of amino acids. Adequate dietary protein is essential for maintenance, growth, lactation and reproduction. Protein is composed of several fractions which vary in their solubility in the rumen. Rumen soluble protein is digested by microbes in the rumen. Rumen insoluble protein passes intact through the rumen to the lower digestive tract. A portion of this bypass (or escape) protein is digested in the small intestine (NRC, 1984; McBride, 1988; Byers, 1990; Babayemi et al., 2014). Cows generally require crude protein in the range of 7 to 14% of daily dry matter intake. Requirement is less for dry cows, pregnant and lactating cows especially dairy cattle require more. Growing cattle, e.g. replacement heifers and steers require from 10.5 to 14% of their dry matter intake to be protein.

Ikhatua and Olubajo (1979b) obtained estimates of 0.63, 0.94 and 1.25 g/day/wt and 0.89, 1.26 and 3.27 g/day/wt digestible crude protein (DCP) requirements for maintenance for Bunaji (WF), German Brown X, N' Dama and German Brown, respectively. The DCP requirements for liveweight gain were 0.032 (Bunaji), 0.019 (GB x N'Dama) and 0.023 (GB) g/day/wt respectively. All the digestible crude protein estimates from this work agreed with the generally accepted standards for digestible nitrogen for other African breeds of cattle given diets adequate in energy. Results from our earlier study Ikhatua and Olubajo (1979b) indicated low nitrogen requirements for tropical breeds of cattle as well as exotic breeds managed under tropical conditions. The observations of Elliot and Topps (1964) that maintenance requirements of DCP of cattle can be reduced by supplementing low quality roughages with concentrate, is a practice normally undertaken during the long dry season. This gave further impetus to investigate the effect of supplementing the all-roughage diets on the DCP requirements of these steers. Consequently, Ikhatua and Olubajo (1979c) found that DCP requirements decreased with supplementation in all the three breeds. The nitrogen balance approach gave values of 1.06, 0.38 and 0.81 (0.75 ± 0.20) g/day/wt while values of 1.08, 0.51 and 1.20 (0.92 ± 0.21) g/day/wt were given by the factorial approach. Results from our earlier study Ikhatua and Olubajo (1979b) indicated low nitrogen requirements for tropical breeds of cattle as well as exotic breeds managed under tropical conditions.

Mineral requirements of cattle

All cattle require mineral elements for cellular respiration, nervous system development, protein synthesis, metabolism and reproduction purposes. Feed resources that contain minerals include range or pasture plants, harvested forages, concentrates and mineral supplements (McDowell and Arthington, 2005; Babayemi et al., 2014). Forage and mineral intake in feed stuff by pastoral grazing cattle depends on the level of mineral consumption. Khan et al. (2005) reported that the levels of minerals in plants is a function of interaction between several factors which include soil type, plant species, stage of maturity, dry matter yield, grazing management and climate. Content of minerals in indigenous forages that grow naturally in Nigeria has been established (Njidda and Isidahomen, 2011; Njidda and Olatunji, 2012). The minerals that often seemed deficient in beef cattle diets are sodium (as salt), calcium, phosphorus, magnesium, zinc, copper, selenium and sulfur (Njidda and Isidahomen, 2011; Njidda and Olatunji, 2012; Babayemi et al., 2014). Attempts have been made to correct natural soil deficiencies for trace minerals by soil fertilization practices. Thus, it is implied that a beef producer needs to know the mineral and trace mineral content of the feedstuffs used in cattle rations. A general approach to prevent such deficiencies is to feed a commercial salt mineral mix developed for the geographic location of the herd:

(a) The salt (NaCl) requirement for cattle is quite low (0.2% of the dry matter); however, there appears to be a satiety factor involved, since almost all animals appear to seek out salt if it is not readily available. Range cattle may consume 2 to 2.5 lb (1kg) salt/head/day when forage is succulent but about half that amount when forage is mature and drier. Signs of a salt deficiency are rather nonspecific and include reduced feed intake, growth, and milk production (Njidda and Isidahomen, 2011; Njidda and Olatunji, 2012; Babayemi et al., 2014). Salt should always be mixed with mineral, because salt drives intake. Cattle have almost zero nutritional wisdom, they do not seek out feedstuffs or minerals when they are deficient, with the exception being sodium, so adding mineral to the salt generally improves intake among cattle with free-choice access to the mineral mix.

(b) Calcium is the most abundant mineral element in the body with about 98% functioning as a structural component of bones and teeth. The remaining 2% is distributed in extracellular fluids and soft tissues and is involved in such vital functions as blood clotting, membrane permeability, muscle contraction, transmission of nerve impulses, cardiac regulation, secretion of certain hormones, and activation and stabilization of certain enzymes (Onyeonagu et al., 2013). Most roughages are relatively good sources of calcium (Onyeonagu et al., 2013). Cereal hays and silages and such crop residues are relatively low in calcium. Although leguminous roughages are excellent sources of calcium, even non-legume roughages may supply adequate calcium for maintenance of cattle. Because lactating beef cows do not produce nearly the amount of milk that dairy cattle do, their calcium requirement is much less. The total ration should provide a calcium: phosphorus ratio of 1.2 to 2:1, with cows at minimum of 1.2:1 and feedlot steers at minimum of 2:1. Ca requirement of growing cattle is 1.2 to 4.4 g/ head /day and lactating dairy cows, 1.6 to 4.2 g/head/day (ARC, 1980).

(c) Phosphorus has been described as the most prevalent mineral deficiency for grazing cattle worldwide (Onyeonagu et al., 2013). Approximately 80% of phosphorus in the body is found in the bones and teeth, with the remainder distributed among the soft tissues. Phosphorus may be deficient in some beef cattle rations, because roughages often are low in phosphorus. Furthermore, as forage plants mature, their phosphorus content declines, making mature and weathered forages a poor source. Most natural protein supplements are fairly good sources of phosphorus. Because adequate phosphorus is critical for optimal performance of beef cattle, including growth, reproduction, and lactation, a phosphorus supplementation program is recommended using either a free-choice mineral mixture or direct supplementation in the diet.

In a phosphorus deficiency, reduced growth and efficiency of feed conversion, decreased appetite, impaired reproduction, reduced milk production, and weak, fragile bones can be expected. Good sources of supplemental phosphorus include steamed bone meal, mono- and dicalcium phosphate, defluorinated rock phosphate, and phosphoric acid. Corn co-products like corn gluten and distillers grains with solubles are also high in phosphorus. Because most grains are relatively good sources of phosphorus, feedlot cattle rarely suffer a phosphorus deficiency, although phytic acid chelation of phosphorus in grains may render up to one-half of it unavailable, especially for monogastric animals such as swine and poultry.

(d) Magnesium maintains electrical potentials across nerve endings. In a deficiency, the lack of control of muscles is obvious. A magnesium deficiency in calves results in excitability, anorexia, hyperemia, convulsions, frothing at the mouth, and salivation, but such a condition is uncommon. Magnesium requirement for cattle is 2 g kg^{-1} DM in the diet (ARC, 1980; NRC, 1996; Babayemi et al., 2014).

(e) Potassium is the major cation in intracellular fluid and is important in acid-base balance; it is involved in regulation of osmotic pressure, water balance, muscle contractions, nerve impulse transmission, and several enzymatic reactions (Onyeonagu et al., 2013). Potassium deficiencies normally are not anticipated in cattle diets because most forages are good sources, containing 1 to 4% (Onyeonagu et al., 2013; Babayemi et al., 2014). A potassium deficiency might be anticipated when diets extremely high in grain are fed (eg, in finishing cattle), because grains may contain < 0.5% potassium. A marginal to deficient level of potassium in growing and finishing cattle results in decreased feed intake and rate of gain. Body stores of potassium are small, and a deficiency may develop rapidly. It is good practice to supplement rations for growing and finishing cattle such that they will contain > 0.6% potassium on a dry-matter basis (Onyeonagu et al., 2013). Potasium (K) of 8 g/kg is recommended for grazing cattle (Underwood, 1981).

(f) Copper and cobalt deficiencies are likely more widespread than previously thought. Cobalt functions as a component of vitamin B_{12}. Cattle do not depend on dietary vitamin B_{12}, because ruminal microorganisms can synthesize it from dietary cobalt (Underwood, 1981). In cattle, therefore, a cobalt deficiency is a relative vitamin B_{12} deficiency, and such cattle show weight loss, poor immune function, unthriftiness, fatty degeneration of the liver, pale skin and mucosa. Copper functions as an essential component of many enzyme systems, including those that involve the production of blood components. Recommended levels of cobalt and copper should be provided in the diet, either by supplementation of the total mixed ration or as part of the free-choice mineral mix or supplemental mix (McDowell, 1992).

(g) Iodine is an integral part of thyroxine and, as such, is largely responsible for control of many metabolic functions. However, some soils do not have sufficient iodine to meet most livestock needs. Iodine requirements in cattle can be met adequately by feeding stabilized iodized salt (Njidda and Isidahomen, 2011; Njidda and Olatunji, 2012).

(h) Selenium is part of the enzyme glutathione peroxidase, which catalyzes the reduction of hydrogen peroxide and lipid hydroperoxides, thus preventing oxidative damage to the body tissues (Njidda and Isidahomen, 2011). White muscle disease in calves, characterized by degeneration and necrosis of skeletal and heart muscles, is the result of a selenium deficiency. Other signs of a selenium deficiency include unthriftiness, weight loss, reduced immune response, and decreased reproductive performance. Selenium can be included in mineral mixes at a level up to 120 ppm so that cattle intake is 3 mg/head/day (Njidda and Olatunji, 2012).

Vitamin requirements of cattle

Vitamins are important for formation of catalysts and enzymes that support growth and body maintenance in animals. Although cattle probably have a metabolic requirement for all the known vitamins, dietary sources of vitamins C and K and the B-complex are not necessary in all but the very young. Vitamin K and the B vitamins are synthesized in sufficient amounts by the ruminal microflora, and vitamin C is synthesized in the tissues of all cattle. However, if rumen function is impaired, as by starvation, nutrient deficiencies, or excessive levels of antimicrobials, synthesis of these vitamins may be impaired (McDowell, 1992).

According to NRC (2001) Vitamin A can be synthesized from β-carotene contained in feedstuffs such as green forages and yellow corn. Vitamin A supplementation should be included in the mineral mix at about 1,200 to 1,700 IUs (International units) per pound of dry matter of feed intake per day. However, this ability varies among breeds; Holstein cattle perhaps are the most efficient converters of carotenes, whereas some of the beef breeds are much less efficient. Therefore, providing supplemental vitamin A to cattle should be considered. Vitamin A is one of the few vitamins that cattle store in the livers. Cattle on a diet deficient in vitamin A may not begin to show signs for several weeks. Newborn calves, which have small stores of vitamin A, depend on colostrum and milk to meet their needs. If the dam is fed a ration low in carotene or vitamin A during gestation, severe deficiency signs may become apparent in the young suckling calf within 2 to 4 weeks of birth, while the dam may appear healthy.

It is a good practice to provide 2 to 5 lb (1 to 2 kg) of early-cut, good-quality legume or grass hay in the daily ration of stocker cattle and pregnant cows to prevent vitamin A deficiency. Most commercial protein and mineral supplements are fortified with dry, stabilized vitamin A. The daily requirements for beef cattle appear to be about 5 mg of carotene or 2,000 IU of vitamin A/100 lb (45 kg) body wt; lactating cows may require twice this amount to maintain high vitamin levels in the milk.

Vitamin A deficiency under feedlot conditions can cause considerable loss to cattle feeders, especially if high-concentrate and corn silage rations low in carotene have been fed. Destruction of carotene during hay storage or in the GI tract, or the failure of beef cattle to convert carotene to vitamin A efficiently, may increase the need for supplemental vitamin A. Growing and finishing steers and heifers fed low-carotene diets for several months require 2,200 IU of vitamin A/kg of air-dry ration. Commercial vitamin A supplements are not expensive and should be used when such rations are fed and any danger of a deficiency exists. An alternative way to supply supplemental vitamin A is by IM injection: studies show that an extremely high dose (6 million U) would be needed to supply adequate vitamin A. As with all vitamins and minerals, a steady supply in the diet is the ideal method for supplementation.

Vitamin D deficiency is comparatively rare in pastoral cattle, because they are usually outside in direct sunlight or fed sun-cured roughage. The ultraviolet rays of sunlight convert pro-vitamin D found in the skin of animals (7-dehydrocholesterol) or in harvested plants (ergosterol) to active vitamin D. Direct exposure to sunlight, consumption of sun-cured feed, or supplementary vitamin D (300 IU/45 kg body wt) prevent a deficiency. Green forage, high quality hay and cereal grains are typically high in vitamin E.

Water requirements of cattle

Water is a fundamental constituent of all living cells. Its presence in adequate amount in the body tissues is an essential pre-requisite for the normal maintenance of life. It is intimately connected with the transformation of nutrients and excretory matter between the digestive system, the cells of the different body tissues, and the excretory organ. Cattle require 3 to 30 gallons of water per day, at the rate of one gallon of water per 45 kg body weight during wet season and two gallons of water per 45 kg body weight during hot weather. Factors that affect water intake include, age, physiological status, temperature, body size, sources of feeds, roughages, concentrates and succulence. To show its significance, French (1956) reported that starving animals may lose nearly all their glycogen and fatty resources, half of their body protein and about 40% of their body weight and still remain alive while the loss of only 10% of body water causes serious disorders and further losses may quickly lead to death.

In the semi-arid/arid regions of the sudano-sahelian ecological zone, drought alternate with seasonal and often short rainy seasons. During the dry season, feed and water can be so scarce that animals do not have enough to eat and drink. This is the plight of livestock owners/herdsmen that drives the transhumant migratory movements to areas with pasture and water. The effect of this seasonal feed and water shortages on the survival and performance of these animals during this period drew researcher’s attention to investigate the influence of restricted water on feed intake, nutrient utilization and nitrogen metabolism of young growing zebu cattle and the West African dwarf goats of the Southern humid rain forest zone. The results of Ikhatua et al. (1985) indicated that feed intake and water consumption were negatively correlated, indicating that as the amount of water intake was reduced, the mean voluntary feed intake (VFI) increased and water to feed ratio increased. It was also observed that apparent digestibility of all the nutrients improved with reduction in the amount of water consumed and consequently resulted in better animal performance in live weight gain. Water reduction did not affect N-metabolism of the bulls.

From these results, it was deduced that the survival ability of these breeds of cattle under water stress and low quality forages available during the prolonged dry season is probably attributed to increased N-recycling as well as a reduction in N-loss during the period. These findings also affirmed that increased recycling of urea into the saliva in the presence of enough energy derived from the feed intake by the animals might have assisted higher rumen function. Working with bucks of the West African dwarf breed fed with maize stover, Ikhatua et al. (1992) observed similar findings as reported with the growing bulls.

CATTLE FEED RESOURCES IN NIGERIA

Forage grasses

Nigerian grassland grows on uncultivated land on which animals have access for grazing. They are found along roadsides and fallow lands in the coastal forest zones of Nigeria. Most of the natural grassland/rangeland assumes more important proportions in the open derived savannah zones of the country. Most farmers rely on natural grassland for their grazing animals. Carrying capacity of the natural grassland is very low compared to that of planted fertilized pastures. Productivity of natural grassland is affected by factors such as soil fertility, the amount of browse species available, density of canopy and management practices such as rotational grazing, stocking rate, fertilizer application, burning and the length of the resting period (Ademosun, 1974; Babayemi et al., 2014).

In the Sahel savannah zone where the rainy season is short and lasts between three and four months of the year, the dominant grass species include *Aristida stipoides* and *Schoenefeldia gracilis.* The Sudan savannah zone which falls within the tsetse fly free zone belt of West Africa is excellent for rearing and breeding of cattle. The grasses in this zone are the quick growing annuals species that reseed easily. The grass species found are *Cenchrus* spp., *Schoenefeldia gracilis*, *Eragrostis tremula, Aristida* and *Loudetia* species, *Pennisetum pedicillatum*, *Andropogon gayanus* and *Andropogon pseudapricus*.

The Guinea savannah zone is characterized by grass species such as *Chloris* spp., *Hyparrhenia* spp., *Paspalum* spp., *Melinis* spp., *Hyparrhenia* spp., *Andropogon gayanus*, *Imperata cylindrica*, *Pennisetum pedicellatum*, *Digitaria* spp. and *Setaria sphacelata.* These tall grasses are replacement for the destroyed forest trees that are characteristic of the Guinea savannah proper, while the Southern Guinea savannah or the tree savannah zone that represents a transitional zone between forests and the savannah zones consist of the following grass species; *Pennisetum purpureum*, *Andropogon tectorum* and *Panicum maximum*.

The productivity, chemical composition and nutritive value of grasses and legumes found in Nigeria vary greatly according to species, the nature and fertility of the soil, water relations; seasons of the year, disease control and the stage of growth at which the grass species are cut or grazed. In the drier northern states of Nigeria where most of the ruminant livestock are concentrated, the prolonged dry season and high temperatures accompanied by rapid deterioration in quality (mostly proteins) of available pasture affects the productivity of animals.

The marked seasonal changes affect the quality and quantity of forage (Aregheore, 1996). Under favourable conditions dry matter yield in the northern savannahs can reach as much as 2,000 kg per hectare, enough to support one to two ruminant livestock units per hectare. However, after the rainy season the quantity of forage declines rapidly and the lack of woody vegetation means that little forage is available in the dry season. Given the short-term availability of high-quality pastures, movement of animals is eminently reasonable and ecologically sound during the dry season (Nuru, 1996; Aregheore, 2001; Aregheore, 1995).

The effect of seasonality on ruminant livestock production is also very important. In the mid wet season, forage biomass is higher in quality and quantity, with crude protein up to 9% in most of the native grasses. Natural grasses and legumes are rich and highly digestible at this period. As the dry season sets in, the protein level drops and the fibre increases. There is an increase in lignin and voluntary intake decreases which makes it a poor feed, resulting in weight loss and decreased fertility and milk yield for 4 to 5 months of the year. The severity and duration of low-quality feed differs from the south to the north within the states. To worsen the ecology and its available food resources further, there is widespread annual burning of native grasslands, thereby drastically reducing the amount of forage on offer (Nuru, 1996).

Thus, a combination of the following factors - low-quality roughage and bush burning, which reduce the biomass available in quantity and quality – have been observed to lead to weight losses ranging from 300 to 400 g per head per day for cattle (Zemmelink, 1974) and up to 15% of body weight in sheep (Otchere et al*.,* 1977).

For example, the crude nitrogen content of *Cenchrus biflorus*, a characteristic Sahelian grass, can drop from 16% in growing plants during the rainy season to 4% in straw in November and only 2.6% in straw in April (Boudet, 1975). For cattle, a nitrogen content of at least 5% is required to prevent weight loss. Without supplemental feed, cattle under these conditions will clearly tend to lose weight and may not survive if they must be driven long distances to market.

During the period of rapid growth the nutrient content of natural grasses on average is about 25% dry matter; 10% crude protein; 6% ash and a fibre content of 35% crude fibre or 43% acid detergent fibre (ADF). As the dry season advances and conditions become severe, their nutritional quality declines to the extent that crude protein could fall to as low as 2%. Ash values also decline to about 3 to 4% as a result of translocation to the root system, while fibre content increases in response to the process of lignification, and sometimes the crude fibre could be as high as 50 or 60% ADF (Smith, 1992).

Forage legumes

Legumes are not generally common in natural grasslands therefore the contribution of fixed nitrogen is usually low. The legumes which include *Stylosanthes guianensis*, *Centrosema pubescens*, *Pueraria phaseoloides*, *Calopogonium mucunoides, Desmodium* spp. and *Atylosia scarabaeoides* are found in the savannahs of the north. There are also a number of tree legumes and multipurpose trees such as *Leucaena leucocephala*, *Spondias mombin*, *Gliricidia sepium*, *Erythrina* spp. that provide foliage for livestock at all seasons of the year (Aregheore, 1995; Aregheore and Yahaya, 2001; Babayemi et al., 2014).

Browse in the form of trees and shrubs forms an integral part of ruminant production since feeding browse has become an essential practice, especially in the dry season when herbaceous forages are scarce and low in nutritive value (Aregheore, 2001). Forage legumes, especially browse plants, are important in the maintenance and survival of ruminants. Large number of browse legumes and multipurpose trees have been tried experimentally and subsequently introduced to ruminant farmers (Mecha and Adegbola, 1980). Browse legumes are shrubs and trees that are of considerable nutritional importance as livestock feed during the dry season of the year (Babayemi et al., 2014). Most nomads and smallholders know them and therefore use them for their livestock (Aregheore, 1996; Onwuka et al., 1992; Carew et al., 1980). The fruits of some form an important feed resource during the dry season.

Many browses contain high levels of essential elements such as calcium, sodium and sulphur as well as critical micronutrients such as iron and zinc which have been shown to be deficient or borderline for productive purposes in many grass species (Olubajo, 1974). In long-term studies that were designed to evaluate the effects of browse supplementation on the productivity of sheep (Reynolds and Adediran, 1987) and goats (Reynolds, 1989), pregnant ewes and does maintained on a basal diet of *Panicum maximum* were supplemented with graded levels of a 1:1 (w/w) mixture of *Gliricidia sepium* and *Leucaena leucocephala* over two reproductive cycles. Supplementation with browse increased growth rate to weaning of both kids and lambs by 45%. Direct supplementation to kids and lambs doubled growth rate from birth to six months in both species. Also browse supplementation increased overall daily dry matter intake by the dams during the final two months of pregnancy and four months of lactation (Smith, 1992).

For example, browse legumes found from north to south; and west to east in Nigeria. Examples are *Leucaena leucocephala, Gliricidia sepium, Acacia* spp. (*A. albida*, *A. nilotica*), *Albizia, Ficus elasticoides*, *Mangifera indica, Musa* sp.*, Spondias mombin, Cajanus cajan, Tamarindus indica,* and *Parkia clappertonian,* to mention but a few (Okoli et al., 2014; Babayemi et al., 2014). Leucaena is widely accepted as the best browse legume and has naturalized in some parts of Nigeria.

Leucaena and *Gliricidia* foliage yields are higher in the wet season (Aregheore, 1995; Balogun and Otchere, 1995). Their leaves provide protein-rich supplements to traditional village diets to increase small ruminant productivity. Dry matter digestibility (DMD) of *Gliricidia* as a sole feed was found to be 54 to 57%, while the addition of cassava tubers (Ademosun et al., 1985a) or cassava peel (Ifut, 1987) raised DMD to 70 to 74%. In a *Panicum maximum* plus *Gliricidia* diet, DMD fell as the proportion of *Panicum* in the diet increased (Ademosun et al., 1985a; Ademosun et al., 1985b; Ifut, 1987; Okoli et al., 2014). For a combination of *Panicum, Gliricidia* and cassava peel, DMD tended to increase as the level of consumption of cassava peel increased (Ifut, 1987). The presence of a fermentable energy source in the diet allows high nitrogen feed such as *Gliricidia* and *Leucaena* to be utilized more efficiently (ARC, 1980). Based on these experiences a small amount of sun-dried cassava peel (about 50 g/day) would be ideal as a supplement (Jabbar et al., 1997).

Yahaya et al. (2001) evaluated the nutritive value of three browse trees (*Ficus polita*, *F. sycomorus* and *Acacia sieberiana)* with sheep on dry matter and crude protein digestibility; and degradability of neutral detergent fibre and acid detergent fibre. Results of the investigation demonstrated that *Acacia sieberiana, F. polita* and *F. sycomorus* can sustain sheep on a maintenance diet and could also be used as a supplementary feed during the dry season.

Browses

Browse has been defined as leaves, shoots and sprouts including tender twigs and stems of woody plants, which are cropped to a varying extent by domestic animals (Devendra and Burns, 1983). It could however, be extended to include the fruits, pods and seeds which provide valuable feed, especially, if the seed is deciduous. Therefore, in the tropics browse plants have been found to give significant potential in terms of adoptability, productivity and acceptability for ruminants in order to balance the difficulties of feed shortages in the dry season (Hutagalung, 1981). In northern Nigeria, traditional herdsmen and other pastoral groups habitually cut down branches from various trees species such as *Acacia* spp., *Adamasonia* spp., *Balanite egyptica* and *Ficus* spp., making them available to livestock during the dry season when no other forage is available (Yahya et al*.,* 2000).

Browse plants, beside grasses, constitute one of the cheapest sources of feed for ruminants. The diversity and distribution of browse plants in Nigeria have received early attention in studies carried out in the north (Saleem et al., 1979), southwest (Carew et al., 1980) and middle belt (Ibeawuchi et al*.*, 2002) of Nigeria. Tree fodders are paramount in the provision of nutrients to grazing ruminants in arid and semi-arid environments, where inadequate feeds supply is a major constraint to livestock production (Aganga and Tshwenyane, 2003). Tree fodders are capable of maintaining higher protein and mineral contents during growth than grasses, which decline rapidly in quality with increase in maturity (Shelton, 2004). Tree fodders form part of the complex interactions between plants, animals and crops (Aganga and Tshwenyane, 2003). They help to balance a plant-animal soil ecosystem from which there is a sustainable source of feeds (Devendra, 1994). The availability of a variety of these feeds and the selection process enable the herbivores, especially the goats, sheep and cattle to extend as well as meet their feed preferences and requirements.

Leguminous trees and shrubs often have thorns, fibrous foliage and growth habits which protect the crown of the tree from defoliation (Njidda, 2010). Many plants also produce chemicals which are not directly involved in the process of plant growth (secondary compound) but act as deterrents to insects and fungal attack. These compounds also affect animals and the nutritive value of the forages. Mycotoxins (fungal metabolites) produced by saprophytic and endophytic fungi are also potential sources of toxins in forages (Norton, 1994). The utilisation of browse is equally limited by the high lignin content and the presence of anti-nutritional factors, which may be toxic to ruminants. However, the toxic compounds seem to become of significance nutritionally only when the plant constitutes a high proportion of the diet. Hence, the effects of high protein forage could override the effect of the toxic compounds when used as supplement in the diets.

The crude protein (CP) content of *Ficus polita*, *Ficus thonningii* and *Leptadenia lancifolia* were reported to be high ranging from 13.85 to 16.65%, which is above the 7% CP requirement for ruminants needed to provide ammonia required by rumen microorganism to support optimum microbial activity (Njidda, 2010). The high CP content of many browse species is well documented and is one of the main distinctive characteristic of browse compared to most grasses. Norton (1998) reported a range of CP contents from 12 to 30% for tropical tree legumes, and Le Houerou (1980) found a mean of 12.5% in West African browse species with about 17% for the leguminous species. Generally, the CP content in browse has been shown to be above the minimum level required (7%) for microbial activities in the rumen (Norton, 1998). The species in the Leguminosae family have a higher protein content compared to other species, although species in the Capparidaceae family have on average 25% more protein than legumes (Le Houerou, 1980).

Le Houerou (1980) also noted that all browse species are able at all their phenological stages to meet the energy requirements of livestock at maintenance level and often well above, and thus West African browse are considered to be excellent fodder, with very few exceptions. The difference in CP content between species can be explained by inherent characteristics of each species related to the ability to extract and accumulate nutrients from soil and/or to fix atmospheric nitrogen, which is the case for legumes plants. The other factors causing variation in the chemical composition of browse forages include soil type (location), the plant part (leaf, stem, pod), age of leaf and season (Njidda, 2010). With regard to the location, some authors have reported that browse plants in the Sahelian zone are higher in N compared to plants in the humid zone (Rittner and Reed, 1992). Younger leaves are richer in N than mature leaves, which however contain more N than the later. The fruits are shown to have a N content in between young and old leaves, and vary little with stage of maturity (Breman and Kessler, 1995). With regard to the fibre content, Rittner and Reed (1992) reported similar mean for NDF and lignin contents across different ecological zones as follows, 40.1 and 11.7% in the Sahelian zone, 45.7 and 10.5% in the subhumid zone and 43.6 and 9.3% in the humid zone respectively. Fall (1993) found a range of 31 to 57% for NDF and 19 to 43% for ADF. In a study conducted by Njidda (2010), NDF and ADF contents in *Ficus polita* and *Ziziphus abyssinica* were considered lower than the values reported by Bibi-Farouk et al*.* (2006) and Sena et al. (1998). These species also had a high lignin content which is a component of the cell wall, and deposited as part of the cell wall-thickening process (Boudet, 1998). Lignin is in general higher in browse than in herbaceous plants. The content varies according to species, age and the plant parts. Positive correlations were reported between contents of lignin and soluble or insoluble proanthocyanidins (Rittner and Reed, 1992). Reed (1986) also found a negative correlation between the content of NDF and soluble phenolics, while the correlation with insoluble proanthocyanidins was positive. The browse forages had low to moderate content of fibre. This is a positive attribute of the browse forages since the voluntary DM intake and digestibility are dependent on the cell wall constituents (fibre), especially the NDF and lignin (Bakshi and Wadhwa, 2004).

The total condensed tannins (TCT) as reported by Njidda (2010) in *Ficus polita* and *Ziziphus abyssinica* browses ranged from 0.15 to 0.39mg/g DM. The level is lower than the range of 60 to 100 g kg DM that is considered to depress feed intake and growth (Barry and Duncan, 1984). However, in ruminants, dietary condensed tannins of 2 to 3% have been shown to have beneficial effects because they reduce the protein degradation in the rumen by the formation of a protein-tannin complex (Barry, 1987). The phenolic content of the browse as reported by Njidda (2010) ranged from 0.24 to 0.65 mg/g DM. The values are lower compared to that reported by Osuga et al*.* (2006). Phenolic compounds are the largest single group of saponin concentrations, and total phenolics in plants can reach up to 40% of the dry matter (Reed 1986; Tanner et al., 1990). In grasses, the major phenolic is lignin that is bound to all plant cell walls, and is a significant limiting factor in their digestion in the rumen (Minson, 1990). Lignin is also a limiting factor in the digestion of legumes, but is bound largely to the vascular tissue (Wilson, 1993), with often high concentrations of other free and bound phenolic compounds (phenolic acids, coumarins and flavonoids) in floral, leaf and seed tissues (McLeod, 1974). Oxalate content in the study conducted by Njidda (2010) was low. It has been reported that 20 g/kg oxalate can be lethal to chicken (Acamovic et al., 2004).

Oxalate has been shown to deplete the calcium reserve, but these *Ficus polita* and *Ziziphus abyssinica* browse species were found to contain resonable amount of calcium, magnesium and phosphorus (Le Houerou, 1980; Akinsoyinu and Onwuka, 1988). Calcium and carbon are also released from the hydrolysis of Ca Oxalate some of which will be either absorbed or excreted by the ruminant animals. With Ca absorption rate of ruminants put at 31% (Randy et al., 1984; Haenlein, 1987) and P at 4% absorption (Adeloye and Akinsoyinu, 1985) reasonable amount of the Ca and P intakes will be lost via faeces and urine to the soil. Such voided minerals/nutrients are thereby recycled for further use to support plants which are ploughed back into the soil, when so much N is returned to the soil. This reduces the use of inorganic N fertilizer and lends weight to the use of organic manure in farming. However, given the time to adapt, the microorganisms in the rumen can metabolise moderate amounts of oxalate.

The mean saponin value as reported by Njidda (2010) was 2.26% with a range of 2.02 to 2.55 mg/g DM. Feedstuffs containing saponin had been shown to reduce methane production (Teferedegne, 2000; Babayemi et al*.*, 2004b). Cheeke (1971) reported that saponin have effect on erythrocyte haemolysis, reduction of blood and liver cholesterol, depression of growth rate, bloat (ruminant) inhibition of smooth muscle activity, enzyme inhibition and reduction in nutrient absortion. Saponins have been reported to alter cell wall permeability and therefore produce some toxic effect when ingested (Belmar et al., 1999). The anti nutritional effects of saponins have been mainly studied using alfalfa saponins. It was observed that 4 to 7 weeks of *ad libitum* feeding of *albizia* gave rise to toxic manifestation in sheep. Symptoms include listlessness, anorexia, weight loss and gastro-enteritis. The toxicity of saponins can be reduced by repeatedly soaking the feed in water, though the level recorded in the study carried out by Njidda (2010) may not pose any problem to the animals.

The phytin levels reported by Njidda (2010) ranged from 2.22 to 5.81 mg/g DM, which is lower than 13.80 to 25.20 mg/g DM reported by Okoli et al*.* (2003) for the southeastern browses in Nigeria. These levels are unlikely to have any adverse effects on ruminants. The HCN contents of the browse species examined by Njidda (2010) were equally low and ranged from 0.05 to 0.08 mg/g DM. The lethal dose of HCN for cattle and sheep is 2.0 to 4.0 mg per kg body weight. The lethal dose for cyanogens would be 10 to 20 times greater because the HCN comprised 5 to 10% of their molecular weight (Conn, 1979). However, the quantity of HCN produced by most tropical browses is too low to pose major animal health problems (Kumar and D'Mello, 1998; Kumar, 2003). Generally, only plants that produce more than 20 mg HCN/100g fresh weight are considered deleterious.

The value for fluoroacetate as reported by Njidda (2010) ranged from 0.0010 to 0.0014 mg/g DM. The value was negligible to pose any problem to animals although if the compound is in large amounts it is known to inhibit the Krebs cycle by formation of fluoroacetate (Everist, 1974) and is used as a poison for rats and rabbits (Norton, 1994a). Available information on browse plants diversity in Nigeria is not exhaustive (Mecha and Adegbola, 1985) and mostly unpublished (Okigbo, 1980; Orok and Duguma, 1987). The report of Okoli et al. (2003) in southeast region contradicts the reports of Wahua and Oji (1987) and Reynolds and Atta-Krah (1987) who respectively identified 35, 30 and 27 browse plants for the entire southeast region. The report of Okoli et al. (2003) indicated that there were much more browse resources in the region than the few highlighted by the studies. Through the help of animal keepers in a farmer-researcher combined survey, these investigators uncovered well over 160 plants consumed by ruminants within the southeastern ecological niche. Some of these plants however, were not common to all the sites studied. Information on the distribution and diversity of browse plants in Nigeria is also lacking (Ahamefule et al., 2006). A detailed study of the browse plants found within 36 states of Nigeria is essential to generate baseline data and to determine the potential browse resource within the major ecological frontiers of the states. The potential yield of browse would provide useful tool for the determination of stocking rate and indeed the carrying capacity of a range or land under grazing. Deforestation, urbanization and bush burning are some of the major factors responsible for dwindling proceeds of browse feed resource for ruminant livestock, especially in northern Nigeeria. Conservatory methods however, would ensure that locally adapted and well established species do not become extinct.

In Nigeria, pasture development has not been developed except on Government and University, experimental, teaching and demonstration farms. The introduction of pasture crops into Nigeria started in the 1950s (Onifade and Agishi, 1988) and over the years pasture agronomists and ruminant livestock nutritionists have investigated pasture plants that could stand the variations of agro-ecological zones (De Leeuw and Brinckman, 1974; Olubajo, 1974; Ademosun, 1974). Scientists in Nigeria have identified suitable pasture plants to meet the variations of the agro-ecological zones, therefore, different grasses and legumes are found in the different agro-ecological zones (Olubajo, 1974; Agishi, 1979, 1983; Onifade and Agishi, 1988).

It will however, require social and cultural changes amongst the nomadic and livestock owners to adopt the technologies that have been developed and to treat livestock ventures as commercial enterprises, and not just a way of life. As part of the new technology in animal husbandry, improved pastures produce more dry matter of high nutritive value and lead to greater animal productivity than do native pastures (Nuru, 1996).

Forage preference of cattle

Short-term preference studies were carried out by Amole et al. (2013) using growing Muturu calves based on diets of local grass forages found in South - Western Nigeria. Two grass species such as guinea grass (*Panicum maximum*) and elephant grass (*Pennisetum purpureum*) at four and eight weeks of re-growth were harvested when needed either for pelleting or for fresh green chop. The diets were served to animals individually and later in group. Feed preference was assessed from the total intake and the chemical composition of each diet was also assessed. The CP content of the grasses ranged from 105 to 133 g/kg DM with pelleted *Panicum* at 8 weeks old having the highest CP. Pelleted grasses of 4 week old had the lowest NDF in the trial. Green chopped *P. maximum* of 4 weeks old was most preferred by the calves. Age at harvest influenced preference as forages harvested at 4 weeks old had higher intake. Forage preference considered in terms of intake rate indicated that growing calves preferred fresh *P. maximum* of 4 week old to the other samples used in their study. Group feeding also influenced forage preference.

Also, Ajayi et al. (2008) reported that if grass of any age is effectively managed, it can strategically be exploited to ameliorate forage scarcity during the off season. An example of these is processing it into pelleted forms, hay and silage which can be stored for feeding during the dry season. Therefore, since ruminants according to Babayemi and Bamikole (2006) are the best assessors of the nutritive value of any feed, as they always consume more of the forages that are high in protein than the high lignin containing grasses, a knowledge of the selectivity of the available forage will go a long way in increasing production and also the establishment of pasture and its conservation through various means such as silage, hay and pellet production to meet the nutritive needs of animals in periods when there is low availability of forage. The researchers concluded that in order to optimize DM intake by animals, farmers should consider the type of grasses and their age at harvest particularly for cattle. Pelleting improves acceptability of forages when rejected by animals in fresh forage form due to advanced age. Forage acceptability by animals on pasture or under zero grazing conditions is also a function of forage, inherent chemical traits, forage morphology. Therefore, effort should be made to encourage farmers to establish and maintain locally available forages that are also adapted to social and environmental conditions of respective areas.

Pasture improvement

About 32.42 million hectares of grazing lands and 39.41 million hectares of crop lands in Nigeria provide substantial amount of feed for the country's livestock, both domestic and wildlife (Magbagbeola et al., 2010; Shiawoya and Tsado, 2011). With the increasing livestock population in the last few years, there is need to increase the quantity and quality of the forages available in the country. Over the years therefore, many improved varieties of forages have been introduced by research institutes, Federal and State Governments with the aim of improving the natural pastures and providing more nutritious feed to the national herds (Ajileye, 1993). There is however, the need to develop or adopt strategies, or technologies that will assist these introduced forage species to cope with and even overcome most of the factors that militate against high productivity. Such technologies should take into consideration the peculiarities of various agro-ecological zones in which these forage and fodder crops grow, in order to obtain useful results for dissemination to livestock producers (Shiawoya and Tsado, 2011).

As part of the new technology in animal husbandry, improved pastures produce more dry matter of high nutritive value and lead to greater animal productivity than do native pastures. Some forage species of promise that have been investigated in the derived savannah zone are *Andropogon gayanus* and *Panicum maximum*. Both proved very productive and palatable and can stand close grazing provided they are well established before being grazed. At moderate stages of growth, *Pennisetum purpureum* is readily grazed and liked by animals. It is also a good forage for silage making when harvested at a height of 2 m and mixed with maize cut at milk stage. The tall grasses have high yield in terms of dry matter but when they get mature, they become coarse, fibrous and rough and the feed value reduces substantially. *Cynodon nlemfuensis,* a spreading perennial, has been used as an improved grass in the derived savannah zone. It can stand close grazing and trampling. It forms an excellent association with *Centrosema pubescens*. In association with *P. maximum* it tends to suppress its profuse tillering characteristics, but it provides an excellent soil cover around bunches of *P. maximum*. Besides the above some other cultivated forage species in the savannah zones are Rhodes grass, Digitaria, and Signal grass.

The use of highly productive good quality pasture grasses and legumes resulted in increased productivity in grazing animals in trials in Nigeria. Research data on both indigenous and exotic forage species in the savannah zones have been reported (Agishi, 1983; Onifade and Agishi, 1988). The use of pasture legumes is advocated to reduce feed deficiencies and the low quality of available feed during the dry season period that constitutes major constraints for optimum livestock production from the savannah rangelands. The use of high yielding legumes as a sole crop or in mixture with grasses is one way of achieving year-round quality forage. Centro (*Centrosema pubescens*) in this regard has emerged as one of the best legumes for the derived savannah and forest zones following initial screening at Ibadan (in western Nigeria) and Shika (in northern Nigeria) (Omokaye, 2001). Thus, due to *C. pubescens* quality it was recommended for sown pastures as well as range improvement and /or rehabilitation (Agishi, 1983).

Omokaye (2001) also examined the effect of sowing date, phosphorus level and stage of maturity on herbage quantity/quality and chemical composition of *C. pubescens* in the year of establishment and reported that forage yields at the initial harvest, yields of regrowth and total yields decreased as planting date was delayed but increased with phosphorus application. Delay of the initial harvest to 14 weeks post planting dramatically increased forage yield while still providing a high quality product. The materials harvested from all treatments, at the initial harvest were high in quality. The N and Ca concentration in centro, even in the unfertilised material were above the critical levels of 1.8% N and 3.5% Ca suggested by Minson et al. (1976) for young beef cattle. Also the P concentrations were above the critical level of 0.12% suggested by Little (1980).

Fodder banking for cattle production

The fodder banking involves the fencing, planting, concentrating, and storing and reserving of forage legumes in hays and silos to which concentrates, mineral and vitamin premixes are added (Mohammed-Saleem, 1986). Fodder banks convert plants such as *Stylosanthes guianensis*, *Centrosema pubescens*, and *Desmodium* spp. into supplementary or fall back forage kept in small to large plots for dry-season use by aging, ailing, nursing, and lactating animals (Tarawali and Pamo, 1992).

The fodder bank concept started in Nigeria in the late 1970's through the activities of the ILRI Sub-humid Programme, Kaduna and involved establishment and management of concentrated units of forage legumes by pastoralists near their homestead (Saleem and Suleiman, 1986). The legumes are fed to "selected" animals as dry season supplementary feed, with 4-ha fodder banks having a potential dry matter yield of 4 to 5 t/ha which would adequately meet the supplementary needs of eight lactating cows during the dry season (Saleem et al., 1986; Saleem and Suleiman, 1986; Otsyina et al., 1987).

According to Haydock and Shaw (1975), the factors involved in fodder bank production in the subhumid zone of Nigeria include land, labour, capital, soil, climate, seed, fire and ants. Understanding how these factors operate under the varying conditions of different parts of the subhumid zone helps to identify the problems and prospects of fodder bank development. For example, the availability of land for fodder banks depends on where a pastoralist chooses to settle since the most common choice is in the vicinity of crop farmers. Fallow land is specifically more attractive because it has less tree and shrub cover and requires less clearing, but there may be difficulties in obtaining it because of rising demand for cropland. Crop farming communities will therefore play significant roles in providing land for fodder banks to those pastoralists settled in their neighbourhood and must eventually benefit from fodder banks or else the intervention will have limited applicability.

Pastoralists settled on grazing reserves or in less heavily populated areas may have easier access to land, but the generally poorer soil and higher ligneous cover of these sites may require a different approach to fodder bank establishment and management. Pastoralists' decisions on how much labour and capital to allocate to fodder banks will determine the area of land that can be used, the method of land preparation and other inputs affecting the productivity and continued existence of the banks.

Crop residues and by-products used in cattle production

Nutrients supply in required quantity and quality is the major setback to livestock productivity in Nigeria. The precarious condition gets worse during the long dry periods when animals are unable to meet their protein and energy needs from available low-quality herbage with consequent marked seasonality in weight loss and productivity (Ademosun, 1994). The utilization of the cheapest and most available feedstuff is a major challenge facing livestock farmers in Nigeria amidst feed crisis (Bogoro, 1997). These cheap feed resources include crop residues, agro-industrial by products, animal processing wastes, brewery waste and by-products, farm animal wastes (poultry litters and animal faeces), and other forms of fibre, protein and energy by-products suitable for ruminant feeding as well as browse plants (Adegbola, 1985; Alhassan et al*.,* 1987).

Crop residues are post-harvest roughage materials or plant materials left after the removal of the primary food from the crop plant. Though sometimes referred to as “farm waste”, they are distinct from agro-industrial by-products which are products arising from factory or household processing of the harvested crop (Alhassan, 1985). Almost all crops cultivated for human consumption contain residual materials which can be consumed and converted to valuable products by livestock. Estimates in Africa alone show that more than 340 million tones of fibrous crop residues are produced annually (Kossila, 1984). Adegbola (1982) estimated that 45 million hectares of savannah land is available for livestock grazing.

Crop residues comprise a vast array of plant materials that vary in their origin as well as their physical and chemical nature. A variety of crop residues are available in Nigeria, some abundant and more useful, others available only in small quantities and therefore of secondary importance. About 22 species of plants are cultivated for human consumption. In Nigeria, 24.6 million tonnes of millet, 17.2 million tonnes of guinea corn, 2.5 million tonnes of maize, 0.2 million tonnes of rice, 1.3 million tonnes of groundnut and 3.7 million tonnes of cowpea residues have been estimated in the major production areas of Adamawa, Anambra, Bauchi, Benue, Borno, Kaduna, Kano and Sokoto States of Nigeria (Alhassan, 1985). It has been observed that most of the crop residues are abundant during the months of September to November (early dry season), while they are mostly needed and utilized between March and July (during the late dry and early rainy seasons) when the available pasture is low in quantity and quality. Some crop residues are used as mulch, bedding, fuel, building materials or source of organic fertilizer. These abundant crop residues can supply enough roughage for the ruminant population in the country if properly harnessed, processed and preserved (Alhassan, 1985). Crop residues are characterized by high content of fibre usually above 40%, low content of nitrogen (0.3 to 1.0%) and low content of essential minerals such as sodium (Na), phosphorous (P) and calcium (Ca) (Adegbola, 1998). Cell wall estimated by neutral detergent fibre (NDF) accounts for at least 72% of the dry matter and represents a large source of potential energy for ruminants. The ability of rumen microorganisms to digest cell polysaccharides, consisting mainly of cellulose and hemicellulose is limited by lignin. Since fibre is often used as a negative index of nutritive value in predicting the total digestible nutrient (TDN) and net energy, the available energy from crop residues is likely to be low in relation to crop residue yield (Van Soest, 1988). The consequences for ruminant animals are low feed intake (about 1.2 kg DM/100 kg live weight) and low performance (Adegbola, 1998). Therefore, crop residues, being fibrous in nature require that their quality be upgraded for effective utilization by livestock.

In general, crop residues are characterized by low levels of one or more key nutrients which limit their utilization by livestock. Cereal stovers and straws which form the bulk of crop residues are inherently low in crude protein (< 60g per kg DM), readily fermentable, metabolizable energy (< 7.5 MJ/kg DM) (Sundstol and Owen, 1984), essential minerals and contain high levels of structural carbohydrate or fibre (Alhassan et al., 1983; Sundstol and Owen, 1984). As a result, the DM intakes (DMI) are too low (about 10 to 15 g DM/kg live weight/day) to permit adequate nutrient intake for maintenance and production. Consequently, when stovers and straws are fed to ruminants, their intake and digestibility are low, resulting in low level of performance.

Generally, when crop residues are fed to ruminants their intake is low and their utilization is limited by the slow rate of, and total degradability and the rate at which particles breakdown to a critical size small enough to leave the rumen. However, leguminous crop residues are usually better and may be used to complement forages if they are in adequate quantities. Crop residues from legumes are usually sold to livestock farmers thereby providing added income for crop farmers. There appears to be no toxic substances in straws and stover, except when they are mouldy. However, phenolics and other aromatic compounds may reduce digestibility in some sorghum and millet varieties (Reed et al., 1988).

Most of these crop residues are utilized by ruminant animals, and can be enriched by different processes some of which can be carried out by small (rural) farmers themselves. Processing of feed involves the use of any treatment which alters the composition of that feed by physical, chemical or biological action (El-Shokshy et al., 1989). Variations in chemical composition and nutrient content of crop residues may be due to: the type of crop, proportion of morphological parts of plant harvested, extent of weathering prior to utilization, chemical characteristics of the soil upon which the crop was cultivated, and level of feeding and fertilization. However, alterations in composition do not simply means improving the nutritional value of the feed but, also include a large range of other improvements such as lengthening the storage life of the feed, detoxification, change in particle size, improving palatability, isolation of specific parts of the feed and reduction in effluent production. The main treatment methods for improving the voluntary intake characteristics and nutritive value of crop residues and by-products are physical, chemical and biological (El-Shokshy et al., 1989). Other methods of improving crop residues and by-products include residue management, breeding and selection, and supplementation.

Physical treatment of crop residues could be achieved by means of milling, grinding and chopping, steaming and ionization. The treatment is generally aimed at reducing the particle size of the material. These are the commonest methods adopted which are aimed at increasing the surface area available to enzymatic digestion of cellulose by rumen microorganisms and to increase the animals voluntary intake. Reduction in particle size increases ease of handling, facilitates better storage, reduces wastage, reduces selective eating by animals and improves feed intake and digestion as relatively larger surface area becomes available for microbial activities.

Several chemicals have been used to upgrade crop residues and agro industrial by-products. The choice of a particular chemical depends on its effectiveness in improving digestibility and intake, cost of treatment, availability and freedom from chemical residues that could be toxic to animals directly or animals and man through faeces and urine polluting soils and water courses. In addition, the chemical should be non-hazardous to handle by man and non-corrosive to machinery. Chemical treatment through the use of alkali such as sodium hydroxide (NaOH), potassium hydroxide (KOH), calcium hydroxide ($Ca(OH)_2$) has been shown to improve digestibility of poor roughage considerably (Klopfenstein, 1978). These alkalis act as delignifying agents by breaking the bond between lignin and hemicelluloses or cellulose. NaOH (caustic soda) has so far been considered the most effective alkali for treating crop residues. Caustic soda has also been shown to have limited acceptability in a growing economy like Nigeria. This is due to its high cost and corrosive nature.

Calcium hydroxide though less expensive and safer to handle with no problem of calcium residue is however weaker than NaOH and needs a long time to react on the crop residue depending on the ambient temperature (El-Shokshy et al., 1989). Furthermore, poor solubility of calcium hydroxide represents a considerable disadvantage to its use and, renders it less effective. Potassium hydroxide, like NaOH is expensive in the pure form. It is also effective in upgrading crop residues and by-products. Wood ash which is a crude form of KOH has been used in treating crop residues by soaking in solution containing 50 g ash/kg residues. Sulphuric acids have been tested for their suitability to upgrade roughages, hydrochloric acid and chlorine (Arndt et al., 1980), nitric acid (Arndt et al., 1980) and formic, orthophosphoric acid or propionic acids. The high cost, unavailability and the danger associated with the corrosive nature of acids place them beyond the reach of the average farmer.

When protein supplements are scarce and expensive, the use of ammonia either in anhydrous or aqueous form becomes advantageous. Treatment of roughages by ammonia has been carried out in most developing countries. It supplies nitrogen to and, delignifies the treated material. The response to ammonia has been found to be highly dependent on temperature, straw variety and moisture content. The straw is usually treated in either polythene covered sack or tunnel using aqueous ammonia or an oven using anhydrous ammonia. However, ammonia treatment of crop residue has been reported not practicable in Nigeria and other developing countries with low technological base because of the unavailability of the forms (anhydrous and aqueous) of ammonia, and even if they are available, the high cost of transportation of gaseous ammonia in special gas cylinders, and the highly technical personnel required to handle this potentially hazardous material do not make them economically feasible.

A safer alternative to ammonia has been urea, which is available in most areas as fertilizer and precursor of ammonia. The use of urea as a precursor of ammonia has been recommended for developing countries for its simplicity and safety in application, availability in local markets at cheap prices and preservative properties (El-Shobokshy et al., 1989). The idea of using urea or poultry litter originated from alkali treatment aimed at breaking the lignin bonds in crop residues like straw, thus releasing the energy contained in them for use by the animal to which these are fed. Ngele (2008) reported an increase in CP from 4.4% in untreated rice straw to 12.4 in 4% urea treated rice straw. However, no decrease in hemicellulose content was observed contrary to earlier reports.

Biological treatment of crops residues is based on the use of certain microorganisms that are very efficient in lignin metabolism but with low degradation rates of cellulose and hemicelluloses. Biological treatment is potentially safer and cheaper than chemical and physical treatment, but the process with unwanted microorganisms may be a disadvantage (El-Shokshy et al., 1989).

Crop residues and by-products management and utilization

Crop residues when allowed to stay for long in the field after harvest, tend to decline in their nutritive value. Alhassan et al. (1987) reported that good crop residue management can be enhanced by packing the residue not later than 28 days after grain harvest. Rainfall tends to leach out the cell contents which lead to a reduction in digestibility of the residue. Also, mouldiness of the crop residues due to high humidity can decrease animal acceptability as well as decrease fermentable carbohydrate. It is therefore important to harvest or graze crop residues on time and handle the harvested materials well to avoid negative effects on the nutritive value of the residues.

Supplementation of low quality roughage is done by feeding limiting nutrients in the form of concentrates (energy and protein), minerals, non-protein nitrogenous (NPN) substances (urea, biuret, poultry litter) or green forages. Supplementation has generally aimed at one or combination of two distinct objectives: Feeding for a positive associative effect; small quantities of supplement are used to enhance intake and, digestibility (Hannah et al., 1991). Supplementation for positive associative effects is usually done when straw is not treated (Leng et al., 1991). In a recent report by Ngele (2008), significant increase in daily total feed intake (DTFI) and daily weight gain (DWG) was observed in rams fed urea-treated or untreated rice straw with various supplements. Mixed supplements (protein + energy) gave better results than single supplements (protein or energy).

The effect of supplementation on intake and digestibility was more marked at lower levels of supplementation that at the higher levels. At higher levels of supplementation, ammoniation had no advantage probably because the ruminal ammonia concentration required for maximum microbial biomass production has been met by the degradation of the supplement. It may be that at this high level of ammonia concentration energy will be a limiting factor. It was also concluded that supplementation with CSC at 1% of the sheep body weight with ammoniated, but not with unammoniated SS, will maintain sheep liveweight. Higher levels with either straw can result in marginal gains while lower levels will lead to liveweight losses.

Adegbola (2002) reported that addition of urea to rice straw increased the CP to 13.67%. Also, a significant increase in total dry matter intake (DMI) was observed. The intake of rice straw was significantly reduced by groundnut hay and CSC supplementation, indicating that a substitution effect has taken place at the levels of supplementation. Both CP intake and digestible CP intake were increased by addition of supplements. Supplementation of rice straw did not affect digestibility of dry matter (DM), organic matter (OM), cellulose and hemicellulose. The pH increased significantly after feeding and was higher for high fibre diets.

CONCLUSION AND RECOMMENDATIONS

Forages have the ability to supply all the energy needed to maintain highly-productive cattle throughout the growing season, but only managed intensively. Legume-grass pasture will easily have protein content greater than 18% during the vegetative stage, as plants mature, the nutrient values lowers. Cattle require 3 to 30 gallons of water per day, at the rate of one gallon of water per 45 kg body weight during wet season and two gallons of water per 45 kg body weight during hot weather. Supplementation of low quality roughage is done by feeding limiting nutrients in the form of concentrates (energy and protein), minerals, non-protein nitrogenous (NPN) substances (urea, poultry litter) or green forages. However, in Nigeria, forage quality and availability vary greatly from season to season which however, affect the output of the animals. The nutritive value of pastures fall rapidly with maturity and, during the dry season, the available feed is lignified. Likewise, protein, vitamins and mineral elements are limited in grassland pastures during the dry season. Crop residues, by-products and browse plants remained the most outstanding feed supplements for cattle and other livestock in Nigeria and elsewhere in tropical Africa. Therefore, fodder banking should form part of the management strategies of livestock industry in Nigeria and Beyond.

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